Insurers in the Greenhouse[+]

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Summary

In the wake of the terrorist attacks of Sept. 11, 2001, increased attention is being focused on the effects of unanticipated catastrophic losses on insurers. In this article we explore the vulnerabilities and disposition of the United States insurance industry with respect to the question of global climate change. The effects of climate change on insurers are expected to manifest primarily through changes in the location, frequencies, and intensities of ordinary as well as catastrophic weather events. Recent history has shown

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that weather-related losses can stress even large insurance companies to the point of insolvency, precipitate elevated consumer prices and withdrawal or restriction of coverage, and generate unrealistic expectations on publicly-funded compensation and relief systems. The difficulty of predicting the impact of climate change creates added actuarial uncertainty and complicates proactive mitigation efforts. Our in-depth interviews with insurance executives and review of the literature found that insurers have assumed positions on the issue at all points of the compass. Few have analyzed the problem in depth. Insurance regulators have also given little attention to the issue thus far, but could play a constructive role in evaluating the magnitude of the problem, anticipating future losses, and promoting strategies to mitigate the causes of climate change.

Climate Change and the Greenhouse Effect

The "greenhouse effect" is a natural phenomenon in which atmospheric gases trap incoming solar energy, thereby making the planet a habitable spherical island afloat in the otherwise cold and desolate environment of space. While the blanket of natural greenhouse gases helps keep the earth warm, it also selectively releases a good share of the incoming solar energy, keeping the planet from overheating.

More than 100 years ago, Svante Arrhenius (a Swedish chemist) first identified the risks of global climate change caused by human activities that generate excess greenhouse gases (Arrhenius, 1896). The problem centers on a build-up of gases like carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons caused by fossil-fuel burning, industrial activity, certain agricultural practices, and deforestation. The result is an increase in land and sea temperatures with numerous potential consequences for human settlements. Atmospheric concentrations of the most important gas, carbon dioxide, are projected to double from their pre-industrial levels within the first half of this century (IPCC, 2001).

A succession of international political summits and scientific and media reports have elevated climate change to one the chief environmental concern of our day.

Every five years, under the auspices of the World Meteorological Organization and the United Nations, the Intergovernmental Panel on Climate Change (IPCC) prepares authoritative, rigorously scrutinized scientific assessments of the state of knowledge on climate change. The most recent assessment[1] concluded that "[t]here is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities," and predicted that average global temperatures will rise between 3 degrees and 10 degrees Fahrenheit by the end of the century—conclusions reaffirmed in Spring 2001 at White House request by the National Academy of Sciences. Insurer

[1] The three-volume Assessment Report (IPCC, 2001) was prepared by 1,337 authors from around the world and reviewed by 1,141 technical experts and government officials. Roughly 10,000 documents were reviewed in the course of the assessment. The report was unanimously accepted in plenary by approximately 100 governments.

authors presented data on rising natural disaster losses (Figure 1) and climate-change risks. Key IPCC findings are as follows:

- Climate science has improved considerably since the previous IPCC review in 1995, providing increased ability of models to project future climates at national and even regional scales.

- Measurable global and regional changes have been observed in the level of greenhouse gases present in the atmosphere, earth's surface temperature, precipitation, extreme climatic events, and sea level. These trends have adversely impacted biological, physical, and socio-economic systems.

- Future warming is inevitable (due to heat already accumulated in the oceans, which is slowly being released to the atmosphere).

- There exist both beneficial and adverse effects of climate change, but, as the scale and rate of change rise, the balance of the impacts becomes negative (Figure 2).

- Adaptation ("mitigation" in insurance parlance) has the potential to reduce adverse effects of climate change but will not prevent all damages, even in wealthy countries that regard themselves as well prepared for natural disasters.

- Numerous options for combating climate change come at zero net cost; e.g., due to the intrinsic cost-effectiveness of energy efficiency investments.

The work of IPCC has been recognized by some U.S. insurers. For example, in their 1998 Securities and Exchange Commission 10K report, Allstate Insurance Company stated:

> *"The question of the magnitude of potential impacts of global climate change will be a continuing source of discussion. However, the Intergovernmental Panel on Climate Change reported that there is a discernable human influence on climate*

change being observed. …[T]his may affect Allstate's potential exposure under its insurance policies."

The insurance industry and others have rightfully noted that some climate changes can be beneficial to human health and settlements (Ross, 2000). For example, a reduced frequency of frost days will lead to fewer crop losses. Conversely, in some cases, perceived benefits are illusory. As a case in point, more precipitation resulting from climate change is not necessarily beneficial for agriculture if it occurs, as is expected, in the form of more intense rainfall events (Rosenzweig *et al.*, 2002).

Many anticipated impacts are defined in local and regional, as opposed to global, terms. The dynamics of wildfire risks (Figure 3) and increasing lightning strikes[2] as a result of temperature increases (Figure 4) are good illustrations.

Insurer Vulnerability: Real, But Difficult to Quantify

Interestingly, the earliest documented statement of insurer concern about global climate change dates back nearly 30 years (Munich Re, 1973).

Insurers today well understand the serious consequences of natural disasters, both for themselves (Figure 5) and for society at large:

"Catastrophes present a significant threat to the U.S. economy and to the domestic property-casualty insurance industry, raising both insolvency and insurance availability concerns."

-- Ross J. Davidson, vice president, corporate finance, USAA Insurance (Davidson, 1996)

[2] Lightning has been cited as responsible for 5 percent of global property-insurance claims, which would be approximately $9 billion annually. Studies have shown that a 1-degree-C increase in average wet-bulb temperature can be accompanied in mid latitudes by a 40 percent increase in lightning. Others found that in a $2xCO_2$ climate with a 4.2-degrees-C warming, global cloud-to-ground lightning strikes would increase by 72 percent over continental regions (Vellinga *et al.*, 2001).

Weather-related events touch almost all types of insurance providers, although the degree of vulnerability varies substantially by insurance line and book of business. Property insurers are more vulnerable than are life and health insurers, although concerns have been expressed for both sides of the industry:

> "One of the most troubling areas [of climate change] will be in that of human health where we will continue to see an increase in respiratory disorders. … There will be more water contamination. … We are also likely to see more environmental health refugees seeking asylum. … We must also consider the Northward migration of tropical diseases…."
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> -- Angus Ross, chief agent (retired), Sorema North America Reinsurance Company (2000)

Within the diverse property segment, some insurance lines are more vulnerable than others. While total available reserves and surplus are large compared to catastrophe losses experienced in the past, not all of these funds are available to pay such losses (Hartwig, 2001). In fact, about 90 percent of these reserves are associated with types of insurance that have relatively little, if any, weather-related exposure (A.M. Best, 2000).

The effects of increased losses can lead to pressure on insurance premiums, sensitivity of insurers' stock prices to major weather-related events, and an elevated rate of insolvencies (Figure 6). Large and small insurers alike have been impacted by weather extremes and will be more so in the future if the intensity of weather-related events increase and/or return periods decrease. The continued insurability of such risks is a central question.

One of the dilemmas facing insurers is the difficulty of disentangling the causes of weather-related losses. This is especially true for those potentially related to human-induced climatic change versus natural climate cycles, and those having to do with human activity that could accelerate *or* dampen the process, such as demographic trends,

increasing property values, disaster mitigation efforts, etc. (Vellinga *et al*., 2001). As shown in Box 1, insurers have linked the upward trend in flooding in part to changes in precipitation (Zeng and Kelly, 1997). In this and other cases, the upward trends in losses have shown to be a product of both human and climatological factors, but in-depth understanding is hampered by technical complexity and insufficient data. One effort by Munich Re ascribed about half of the past rise in global losses to climate change and the remainder to socio-economic trends (Munich Re, 1999).

Insurers first participated in the work of IPCC in 1995, with General Accident leading the authorship of an entire chapter devoted to the question (Dlugolecki, 1995). Two chapters in the subsequent IPCC Assessment, coauthored by insurance industry representatives from Germany, Japan, Canada, Switzerland, the United Kingdom, and the United States focused a diversity of potential climate change impacts on insurers (Table 1) (Vellinga *et al.*, 2001; Cohen *et al.,* 2001).[3] Among their findings:

- A wide range of insurers are vulnerable to the consequences of climate change (property, business interruption, crop, life/health, etc.) (see Table 1).

- The historical trends in insurance loss statistics are consistent with what would be expected under climate change.

- There is high confidence that climate change and associated changes in weather-related events would increase actuarial uncertainty in risk assessment, thus adversely affect the functioning of insurance markets (e.g., pricing and availability).

[3] In addition to a variety of climate scientists, insurance and banking, industry co-authors included representatives from CGU, Credit Suisse, The Insurance Bureau of Canada, Munich Re, and Tokyo Marine & Fire Insurance, Co., Ltd., and an actuary from the United States.

- Despite isolated benefits (e.g., fewer frost days), climate-change scenarios will result in elevated potential for insurer insolvencies, for large and small firms alike (see Figure 7).

- Insurability concerns will put increasing pressure on the government sector to assume certain risks, but governments will resist this tendency.

- Various climate-change prevention strategies offer interesting business opportunities for insurers (e.g., new services to customers and new products, such as insurance of contracts to reduce emissions).

Regardless of the causes of past losses, a problem looking forward is that climate science is rarely designed to address questions of importance to insurers. The growing use of catastrophe ("CAT") models is a step in the right direction, but these models are hamstrung by virtue of being predicated largely on past experience rather than scenarios incorporating future climate change. These models also fail to capture smaller-scale, but more frequent, events of concern such as wildfire, lightning strikes, localized flooding, and soil subsidence (contraction/expansion of soil as a function of moisture content or frost heave). The proprietary "black-box" nature of these models hampers efforts to validate them.

An overarching issue is that, from an actuarial standpoint, increasingly variable and unpredictable, non-linear patterns of extreme weather events can imply greater statistical uncertainty (unpredictability) of potential losses (Peara and Mills, 1999). This can present a material impediment to setting actuarially sound rates.

> *"Insurers rely upon their ability to predict the economic consequences of future events. That's how premiums are set; that's the kind of assessment they do of their own exposures. In a period of changing climate, when the very basis of their decisions may be changing, then they need to have a better understanding of climate change. … The fact that future events may not be a linear progression of*

the past, but in fact may have changed as a result of natural variability, or human activity or whatever, is an important thing to be taken into consideration."

-- Franklin Nutter, president, Reinsurance Association of America (*Business Insurance*, 1998)

Comprehensive analyses of global insurance sector vulnerability to past or future climate changes have not been undertaken. A brief paper prepared by the American Insurance Association (AIA) estimated that about 20 percent of U.S. insurance property-casualty premiums are associated with types of insurance with "significant" exposure to weather-related loss, 2 percent with "moderate" exposure, 66 percent with "minor" exposure, 9 percent with "minor to no" exposure, and 4 percent with "no" exposure (AIA, 1999). The large "minor" category is primarily auto insurance, which may have more vulnerability than assumed by AIA (Box 2). The paper did not evaluate other measures of vulnerability, such as profitability, solvency, or exposures according to other metrics; e.g., total insured property values for which the at-risk insurers are responsible.[4]

Studies such as AIA's are an important starting point, however, and highlight the need for segmenting and taking into account the financial complexity and diversity of the insurance sector, rather than regarding it as a monolith. AIA's paper also points out that a connection between hurricanes and climate change has neither been established nor disproved. Ironically, the observed reductions in North Atlantic hurricane frequency could be consistent with climate change.[5] In any case, the question of hurricane risk is too often singled out, in light of the diversity of vulnerabilities outlined in Table 1.

[4] For example, $4 trillion in insured property in the Gulf and Atlantic coastal counties of the United States (Hooke, 2000).

[5] Hurricanes form through a conjunction of several meteorological factors, in addition to the warmth of the sea surface. Atmospheric conditions are extremely important. It is quite possible that global warming will result in a change in atmospheric conditions, e.g., greater volatility that may result in disrupting the seed of the hurricane cell, thereby impeding the development of a severe cyclone. A second argument on this point is that, statistically, severe hurricanes do not form in El Niño years. If, the frequency of El Niño conditions increases as expected under climate change (Timmermann et al., 1999; Collins, 2000; Meehl et al., 2000), history suggests there will be fewer hurricanes. IPCC has far more certainty that tropical cyclones will increase under climate change.

The AIA paper insightfully notes the importance of proactive land-use planning and that certain measures normally thought of as valuable only for avoiding climate change (e.g., emissions reduction achieved through public transportation or reduced highway speed limits) can also offer benefits to insurers by reducing everyday risks.

Notions of vulnerability tie directly back to reserves and surplus. Reserves for the most vulnerable lines identified by AIA: commercial multi-peril and homeowners multi-peril were approximately $37 billion (11 percent of the total) in 1999, with an additional $6 billion provided through reinsurance. Moreover, surplus must be available for payment of all kinds of losses (Hartwig, 2001). Interpretation of the aforementioned AIA analysis may suggest to the casual reader that about 20 percent or more of total surplus would be available for losses related to climate change. The actual values (for 1999) are, however, 7.6 percent for commercial multi-peril and 2.8 percent for homeowners multi-peril (A.M. Best and Co., 2000).

Individual firms would become insolvent long before losses approach the industry's aggregate capacity. While reinsurers offer additional capacity, a general consensus as of the late 1990s suggested that the capacity of insurers and reinsurers to absorb a single major catastrophe is low compared to the maximum probable loss. Analyses in the wake of 9/11 have again underscored the finite nature of reinsurance capacity, and the sensitivity of their profitability (combined ratios) to catastrophic losses.

The threat of insolvency is often assumed to apply exclusively to small firms. Following Hurricane Andrew, however, Florida's two largest homeowners insurers, State Farm Fire & Casualty and Allstate Insurance Company, would have faced insolvency had it not been for infusions of funds from their national parent companies (Mills *et al.,* 2001). Of the nearly 700 U.S. insurers that became insolvent between 1969 and 1999, about 10 percent were primarily due to natural catastrophes, and for an unknown additional share catastrophes were a contributing factor (Matthews *et al*.,1999).[6]

[6] Approximately 20 insolvencies were attributed to natural disasters during the period 1989 to 1993 (Snyder *et al.,* 1999).

An important shortcoming of most previous analyses is that they typically focused on single events, while, in reality, insurers can be faced with simultaneous or sequential losses or other sources of financial stress. Major industry losses, like Hurricane Andrew, can set off chains of events that destabilize the industry. Examples of these "after shocks" include reinsurance spirals, rapid escalation in reinsurance costs that force primary insurers to limit operations, or the failure of reinsurers to pay their claims—setting off a domino effect of other company failures.

Global Loss Trends

Over the past 50 years, the number of weather-related natural disasters has been steadily rising, as have the total and insured losses (see Figure 1). Munich Re's Geosciences Group (2000) has tabulated that over the 1985 to 2000 time period, the nations of the world endured nearly $1 trillion dollars in economic losses (and 170,000 fatalities) due to 8,800 natural disasters. Three-quarters of the aforementioned losses were weather-related.

After subtracting the effects of inflation, global weather-related insurance losses from *large* events escalated from a negligible level in the 1950s to an average of $9.2 billion per year (excluding loss adjustment expense, which run approx. 13%) in the 1990s—or 13.6-fold for the 1960–1999 period where detailed base-year data are available. Insured losses as a percent of gross domestic product also rose. Global population grew a relatively low 2.4-fold since 1950.

Disproportionate amounts of attention are afforded to the headline-grabbing multi-billion dollar loss events, given the equally large (albeit more distributed) collective costs of relatively minor events expected under climate change. For example, the average annual cost of tornadoes and associated hailstorms is larger than that of hurricanes or earthquakes. If one includes mid-size weather-related loss events—more than 600 of which are documented every year—the economic losses cited above double in size

(Munich Re, 1999). Large loss events represent only 1 percent of the total number of weather-related events annually.

Even these numbers are underestimated, since numerous relatively small events are not systematically recorded. For example, the insurance industry's Property Claim Services (PCS) tabulated only those losses of $5 million or more up until 1996 and those of $25 million or more thereafter. As a result, no winter storms were included in the statistics for the 46-year period of 1949–1974, and few were thereafter (Kunkel *et al.,* 1999). Similarly, weather-related vehicle losses are typically not captured in the statistics except when they occur within the context of large catastrophic events (Box 2).

One often-overlooked class of small events are those involving damage to buildings or other infrastructure due to soil subsidence, lightning, ordinary hailstorms and windstorms, and coastal erosion. Subsidence losses from two droughts in the 1990s resulted in losses of $2.5 billion in France and even more in the United Kingdom (Vellinga *et al.,* 2001).

It is clear that the costs of weather events have risen rapidly, despite significant and increasing efforts at fortifying infrastructure and enhancing disaster preparedness.[7] These efforts have dampened to an unknown degree the observed rise in loss costs, although the literature attempting to separate natural from human driving forces has not quantified this effect.

> *"One can easily hypothesize that increasing population and urbanization in the United States has led to a commensurate increase in population at risk. Yet, one can also hypothesize that the various societal responses may have more than compensated for population growth and in fact fewer people are today at risk."* (Kunkel *et al.*, 1999)

[7] These efforts include use of geographic information systems to better understand and pinpoint risks, land-use planning, flood control programs, mitigation along coastlines, cloud seeding to divert hail storms, improved building codes, tightened zoning, improved weather forecasting and storm warning systems, and public spending on disaster preparedness and recovery.

Notably, the growth rate in the damage cost of non-weather-related and manmade losses was one-third that of weather-related events for the period 1960–1999 (Munich Re, 2000). The observed upward trends are consistent with what would be expected under human-induced climate change.

United States Loss Trends

The United States bears a disproportionate share of the global natural disaster losses. During the 15-year period 1985–1999, the United States experienced 14 percent (1,264) of global weather-related catastrophic loss events, 31 percent ($290 billion) of the economic costs, and 58 percent ($110 billion) of the insurance losses (Munich Re, 1999).

Between the mid-1950s and the mid-1990s, the U.S. population grew by 1.5-fold, the number of catastrophes by 5-fold, and catastrophe losses by 10-fold (Easterling *et al.,* 2000). The $98 billion in inflation-adjusted insured catastrophe losses in the 10-year period 1989–1998 were nearly twice as high as the total of $49 billion in losses for the 39-year period 1959–1988 (ISO, 1999).

Some types of losses have grown particularly fast. Storms causing losses in excess of $5 million grew 60-fold to $6 billion per year between the 1950s and the 1990s (Easterling *et al.,* 2000).

As a broad measure of the implications of these trends for insurers, the gap between United States losses and insurance premium income has narrowed by nearly six-fold over the past 30 years and, briefly, by as much as 20-fold following Hurricane Andrew in 1992 (Figure 8).

In addition to domestic losses, a given insurer's vulnerability often extends beyond the borders of the country in which it is domiciled. For example, U.S. insurers collected $35 billion in premiums for overseas insurance sales in 1997. Such insurance has been

growing faster than overall premiums in recent years. Thus, U.S. insurers are also exposed to the impacts of climate change outside their national borders, increasingly in areas—such as developing countries—where vulnerability is high and preparedness is low or nonexistent.

The Uncertainties of Future Losses

Historical trends are not reliable predictors of the patterns of natural disasters under future climates. Whether due to human-induced or natural forces, insurers are faced with the need to better prepare themselves to withstand natural disaster losses and to more effectively analyze their exposures and associated uncertainties.

Realistic future scenarios involve multiple, coincident events; e.g., consecutive (or overlapping) natural disasters, taking place during times of weakness in financial markets and/or non-weather related losses. This was witnessed before in the case of the Great Depression and the Dust Bowl. Indeed, the impact of the terrorist attacks of Sept. 11, 2001, was amplified by a simultaneous downturn in the financial markets, the collapse of Enron, a recession, a steep decline in the securities markets, and emerging risks (e.g., toxic mold). On top of this, earthquake losses present severe threats to some regions of the country. In some areas, such as the New Madrid fault zone, earthquake risk is concurrent with storm-related catastrophe risk.

Hybrid events involving multiple sources of insurance losses are of particular concern, and entail correspondingly more actuarial uncertainty. This is exemplified in the case of El Niño events—expected to increase under climate change—which, as seen in the Northeastern Ice Storm of 1998, can involve various simultaneous damages from rain, ice storms, floods, mudslides, and wildfire and a corresponding diversity of insurance losses (property, business interruption, additional living expense, life/health) (Lecomte *et al.,* 1998). As shown in Figure 9, sea-level rise is another multifaceted risk, with impacts on flood insurance (via inundation and flooding), property insurance (through coastal

erosion), and health and crop insurance (through seawater intrusion into fresh groundwater lenses).

Insurer Perspectives and Initiatives

Managing natural disaster risks is a recent challenge in the history of insurance (Mills *et al*., 2001). It was not until 1955 that insurers in all states could offer multi-line policies and were accepting a diversity of risks ranging from fire to wind to lighting. The science of understanding and mitigating the fire risk remains even today far superior to that of other natural hazards.

> *"A.M Best Co. believes that the industry is still in its infancy stage of catastrophe management, and that there may be regions where true catastrophe exposures are still to be unveiled, leading to potential insolvencies ... A.M. Best views the potential "mega-catastrophe" as the most serious financial threat to the industry."*
>
> -- Patrick Matthews *et al.,* A.M Best Co. (1999)

Looking forward, climate change represents a worst-case scenario for natural disaster risks. In response, approximately 90 insurers from 27 countries are currently collaborating under the United Nations Insurance Industry Initiative for the Environment. With few exceptions, U.S. insurers, however, have devoted relatively less attention to the issue than their counterparts in Asia and Europe and few have joined the initiative.

The authors conducted interviews with 28 United States insurance executives and others in the industry and reviewed more than 300 publications from the scientific and insurance trade literature (Mills *et al.,* 2001). We encountered tremendous variability in the nature and degree of awareness and interest in the climate change issue. The result naturally depicts a diversity of opinions and perspectives, rather than a polished and internally consistent position.

The words "climate change" stir anxieties and arouse controversies among some insurers. While a number have given some attention to the issue in the United States, the vast majority of individual firms and most trade organizations have not publicly indicated an opinion. As illustrated by the following quotations, a few have taken definitive positions that there is a material threat. Others have adopted equally strong views to the contrary. Some have elected to pursue research while fortifying society against climate change. The majority have adopted a strictly "wait-and-see" approach.

> *"The insurance business is first in line to be affected by climate change. It is clear that global warming could bankrupt the industry."*
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> -- Franklin Nutter, president, Reinsurance Association of America (cited by Linden, 1994)

> *"We live in a time when the increasing frequency and severity of natural disasters is a near certainty."*
>
> -- Jack Webber, president, Home Insurance Federation of America (cited by Federal News Service, 2000)

> *"Yes, climate change is real. To think that all of the chemicals we release into the air doesn't influence the chemical balance of the atmosphere is beyond my comprehension. I believe that once science has enough data to show statistically significant changes, the momentum of the damage will require a long timeframe to counteract the changes. To me, proving that earth's climate is changing from human actions—namely global warming—is like statistically "proving" the pavement exists after you have jumped out a 30-story building. After each floor your analysis would say 'so far - so good' and then, at the pavement, all uncertainty is removed."*
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> -- Richard Jones, vice president, engineering, Hartford Steam Boiler Insurance & Inspection Company (2000)

"Good science is on the side of global warming. The ones throwing the spitballs are the skeptics, and their motives are clear. ... But until we separate the junk from the science, an intelligent debate can't even begin. ...Financial ties to those with a vested interest in seeing that greenhouse gas emissions go unrestricted don't make these men liars. When Tiger Woods tells me that Buick makes a fine automobile, it's quite possible he's telling the truth. But I would certainly want to consider the fact that Buick paid him $30 million to reach that conclusion before I ran out and bought one."

-- Aaron Newhoff, Chief Actuary, Becher & Carlson, Insurance Brokers (2000)

"As the reality of global warming sets in, the factors that are causing this trend and its effects on extreme weather patterns—from floods to droughts to hurricanes—concerns all businesses and communities."

-- Risk and Insurance Management Society (*Rimscope*, 2000)

"As we are beginning to appreciate within the reinsurance industry the effects of climate change can be devastating . . . Together with other members of the insurance industry who adhere to the UNEP Statement, we can make a positive contribution to the development of sustainable solutions to the pressing environmental issues which face our global society."

-- Kaj Ahlman, former CEO, GE Employers Reinsurance Corporation (UNEP, 1998)

Interestingly, United States insurer involvement in the issue was markedly greater in the early 1990s than it is today. This is particularly apparent in the case of the Insurance Institute for Property Loss Reduction, now the Institute for Business and Home Safety (IBHS), which in 1995 assured then Vice President Al Gore it would take further action on the issue representing its diverse insurance industry constituency (Mills *et al.,* 2001).[8] IBHS' involvement, however, dropped sharply thereafter.

[8] One of the authors (E. Lecomte) was president and CEO of IIPLR at the time.

Of course, insurers have a number of traditional tools for reducing their vulnerability. These include purchasing reinsurance, asking regulators to raise rates, restricting coverage, non-renewal of existing policies, and withdrawal from overly risky markets. They may also limit their liability by capping amounts of insurance available, placing special limits of liability on coverage, providing coverage on an "actual cash value" basis instead of replacement cost, and increasing deductibles. They can pool their risks, look to residual market mechanisms, or strive to increase their investment income, and, if sufficiently burdened, reduce dividends to shareholders and/or policyholders. Implementing some of these measures may require legislative or regulatory action and present political and market risks. Meanwhile, insurers—in consort with other parties—also possess a diverse toolkit of engineering approaches to managing and minimizing losses caused by natural hazards. However, it is clear that losses continue to rise at a considerable rate, and mitigation efforts have clearly fallen far short of the desired goal.

Insurers are also able to transfer or share losses with special government risk sharing programs, self-insureds, consumers, and the capital markets. As insurers rightfully point out, not all risks are commercially insurable. Government-sponsored coverage of climate-related risks like crop and flood insurance has effectively insulated U.S. insurers from the full scope of climate-related risks,[9] although private insurers absorb some of these losses and some perceive this risk to be growing in the face of climate change (Box 1).

Partially as a result of government insurance programs, United States insurer attention to climate science has focused largely on wind-related hazards (particularly hurricanes). Relatively little effort has been spent on evaluating other climate-related risks. This narrow focus is justified to a degree given the dominance of windstorms in insurance claims in recent decades, but it also predictably leads to a less-than-comprehensive and less proactive perspective on the climate-change phenomenon.

[9] Total estimated losses from the 1988 United States drought were $56 billion, and those from the 1993 Mississippi River Valley floods were $23 billion ($1998). Combined U.S. flood losses for the period 1987–1997 amounted to approximately $65 billion ($1995) (Rosenzweig *et al.,* 2000).

Meanwhile, seeking reductions in private sector insurance coverage for climate- and weather-related hazards produces increased pressure on government to assume the associated risks. Federal and local governments, however, have repeatedly shown reluctance to increase existing insurance exposures and liabilities for providing disaster relief. Governments are increasingly being looked to as insurers of last resort for mold-related claims, nuclear power liability, wildfire, and other hazards. This tension is a central dilemma facing society and policymakers in the face of rising catastrophe losses.

> *"Either a mega-catastrophe or a series of closely occurring disasters could greatly strain or overwhelm the capacity of the insurance industry and result in large federal payments for disaster relief."*
>
> -- United States General Accounting Office (1994)

Moreover, insurance regulators and public-sector disaster management officials often find themselves politically constrained. According to some, insufficient recognition of the risks has led in some cases to a false sense of security and mal-adaptations.

> *"Economic and political pressures have forced state officials to restrict the necessary adjustment of insurance markets to catastrophe risk, which has created a false sense of security … The scary reality is that state insurance mechanisms and many private insurers will be bankrupted by a mega-catastrophe and will not have enough money to cover the claims they have promised to pay. This will force federal and state governments, and ultimately taxpayers, to step in and cover the gap.*
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> *Because of the way state insurance mechanisms, tax policy (e.g., deductibility of insurance losses), and insurance guaranty funds are structured, approximately three-quarters of an insolvent insurer's deficit would fall on taxpayers and policyholders of solvent insurers … The unfortunate fact is that government spending, tax and regulatory policies allow high-risk communities and property*

owners to externalize a substantial portion of their catastrophe losses to all Americans."

-- Robert Klein (1997)

With some notable exceptions, the preponderance of relevant United States insurer activities fall in the area of pre- and post-disaster loss mitigation, rather than involvement in climate science or engaging in the public policy discussion about mitigating climate change itself. This reflects a reactive versus proactive approach to the issue. Moreover, we have seen no quantitative analyses from insurers of how climate changes could affect hazard mapping or the probable maximum loss estimates and return periods upon which insurance pricing and planning rest.

Many of the insurance executives we interviewed exhibited a genuine desire to make a contribution toward safeguarding the public and their policyholders. However, most claimed to lack the scientific knowledge needed to participate in the climate-change debate. Ironically, some stridently declared a lack of expertise, yet stated with authority that climate change is not taking place.

Qualitative differences between the activities and statements of United States and foreign insurers are often noted. Asian and European companies have been particularly outspoken (Quirke, 1994), as have those in Canada. The primary differentiating factor is the relative interest of non-U.S. insurers in the "precautionary principle," and an understanding that *both* natural and human-induced climate changes are at play.

"Climate change is already affecting our lives. ... The Precautionary Principle of recognizing that the risks of doing nothing are greater than the risks of doing something is now embedded in international legislation, graphically so in the case of the Kyoto Protocol. ... The insurance industry has a pivotal role to play in this process….

-- AON (2000)

"The situation we are in resembles that of a driver who approaches a wall of fog and, having only a vague impression of the stretch in front of him, looks into the rear mirror in an attempt to see in the clear view of the road behind some indication of what lies ahead. ... There are some drivers on this earth that, instead of stepping on the brake, are putting their foot down firmly on the accelerator. ... Mankind is in the process of performing a gigantic experiment on the earth's climate. However possible it may still be to argue about the development of climate change and particularly about its effects, there are definite indications that the risk situation will deteriorate in the future. Every effort must be made to mitigate climate change and to restrict the impact as much as possible."

-- Munich Re (1999)

"Risk management views the public discussion on climate change as a rabbit sitting paralyzed in front of a snake—unaware that behind it a fox is poised to strike. There is not one problem but two: natural climate variability and the influence of human activity on the climate system."

-- Swiss Re (1998)

"Some are of the opinion that no major actions should be taken until the evidence of climate change is more certain and the link to increased frequency and severity of climate-related natural disasters is verified. However, to delay taking action until the scientific conclusions are confirmed may be extremely risky as irreversible changes may have already occurred and additional enormous economic and human losses may have been suffered through natural disasters which could have been prevented or mitigated against. It would appear that sufficient economic and social benefits may flow from actions that improve disaster prevention and mitigation to justify these activities on their own merits."

-- Institute for Catastrophic Loss Reduction (Bruce *et al*., 1999)

Underlying these differences are the relative roles of science and analysis within insurance companies, a longer history of insuring natural hazards in Europe, the sheltering role of government flood insurance in the United States, proactive versus reactive approaches to loss prevention and mitigation, and the perception or lack thereof of new business *opportunities* presented by climate-change risks. Likewise, the regulatory and tax-law environment, as well as the tone and tenor of government relations with insurers, and differences in corporate culture, relationships of corporations with non-governmental organizations, and the timeframes with which insurers measure their futures differ dramatically.

LESSONS FROM 9/11

While on the surface quite removed from the question of climate change, the terrorist attacks of Sept. 11, 2001, have numerous parallels (Challis, 2002), such as:

- 9/11 is a striking reminder that past experience is not necessarily a predictor of the future. The event dramatically surpassed the insurance community's conventional wisdom about maximum potential losses, redefining the imaginable and creating the "worst year in the history of the property-casualty insurance industry," according to the Insurance Information Institute.[10] Under climate change, the incidence of severe events can exhibit considerable breaks from historical trends. This has material implications for regulatory rules concerning methods for projecting losses in the future. In particular, current data and modeling methods used by insurers are inadequate for projecting losses under a changing climate.

- 9/11 highlights the multi-dimensional insurance impacts that can result from mega-catastrophes, spanning property, workers' compensation, life/health, business

[10] As has been observed following major weather catastrophes, there were dramatic effects on profitability and challenges to insurer solvency. The industry as a whole lost $3.5 billion in 2001, as opposed to $10 billion to $40 billion in net annual income after taxes for the 1993–2000 period. U.S. reinsures' combined ratio rose from 114 percent in 2000 to 142 percent in 2001 (*Business Insurance*, March 18, 2002, p. 1).

interruption, etc. The experience parallels the great diversity of insurance lines potentially impacted by a single weather-related catastrophe.

- Both 9/11 and climate change raise key public policy questions about the fundamental insurability of catastrophic losses, and the relative roles of private and public sectors, with increased emphasis on the government sector as "insurer of last resort."

- 9/11 has put considerable pressure on insurance and reinsurance prices, and stimulated increased interest in self-insurance.

- Lastly, the events of 9/11 represent the first "life insurance catastrophe" in U.S. history (Hartwig, 2001). Similar surprises could likely be associated with climate change (e.g., urban heat catastrophes, flood-related fatalities, public health problems resulting from water service disruption or waterborne diseases, etc.) (Ross, 2000).

No-Regrets Opportunities

Energy consumption is the primary human source of greenhouse-gas emissions. The insurance industry seemingly has little concern about energy issues, other than the conventional risk-management issues associated with energy supply systems. However, examination of the connection between risk management and energy efficiency, has identified nearly 80 examples of energy-efficient and renewable energy technologies that offer "loss-prevention" benefits for many branches of the insurance sector (Vine *et al.*, 1999; Mills, 1997).

- *Energy End-Use Efficiency.* Examples include the replacement of fire-hazardous, energy-inefficient halogen lighting with efficient compact fluorescent lamps and improved insulation and equipment efficiency to reduce the vulnerability of structures to extreme temperature episodes. Other examples include increased use of public transit

and reduced speed limits and improved highway safety (AIA, 1999). Interestingly, the Insurance Institute for Highway Safety has recently come out in favor of automobile efficiency standards, based on a new approach that improves fuel economy without compromising safety (Beattie, 2002; Ross and Wenzel, 2002). Emission reductions achieved through energy efficiency can translate into improved urban air quality, and reduced respiratory disease. Certain energy management strategies also stand to offer insurance benefits in terms of *indoor* air quality risks (Chen and Vine, 1999).

- *Renewable Energy and Distributed Energy Systems.* Certain renewable and distributed energy supply technologies have attributes relevant to insurance loss prevention or support disaster preparedness and recovery. For example, low-power/energy-efficient technologies can reduce business-interruption risks by extending the reliability and operating range of backup power systems (Lecomte *et al.,* 1998; Deering and Thornton, 2000; Gordes, 2000). Renewable energy sources can yield health benefits through improved regional air quality.

Material steps in this direction have been taken by over 50 forward-looking insurers and reinsurers, brokers, insurance organizations, and non-insurance organizations (Mills, 2002a). The approaches can be grouped into the categories of information, education, and demonstration; financial incentives; specialized policies and insurance products (Mills 2002b); direct investment; customer services and inspections; codes, standards, and policies; research and development; in-house energy management; and an emerging concept informally known as "carbon insurance."

To be successful, the above-mentioned strategies must address acute strategic issues faced by insurers. A good example is the rapid growth in mold and indoor air quality claims and construction defects litigation haunting many U.S. insurers. Some of these claims trace back to bad design and application of energy-related systems. The growing insurance risks associated with electricity reliability are another example (Eto *et al*., 2001; Mills, 2001) that can be addressed, in part, through efficiency and distributed renewable energy supply solutions.

Policy Implications For Regulators

Climate change warrants the keen consideration of regulators, given their dual responsibility to guard policyholders' interests and to ensure the solvency of insurers so that they can meet their financial obligations when disaster strikes. In doing so, regulators must look at alternatives that will lessen the financial impact on insurers at the time of loss. Furthermore, regulators experience political risk if rates rise considerably in response to elevated natural disaster losses.

Regulators also have to cope with queries from state legislators, as was seen in New York hearings on climate change in 1999 where Alexander Grannis, chair of the New York Assembly's Insurance Committee, called for insurers to take greater interest in the issue.

Whether or not one subscribes to the scientific assessments signaling impending climate changes, it should be reasonably non-controversial to say that better analysis and information can only help to isolate and manage risks.

United States insurance regulators have thus far given fleetingly little attention to the subject (as evidenced by only one past article in the *Journal of Insurance Regulation* on the subject (Quirke, 1994)). Based on our literature review and executive interviews, we found that insurers' inaction on climate change can be traced in part to the virtual absence of "signals" from their regulators on the importance of the issue. This is reinforced by the industry's historic pattern of "cash-flow underwriting."

Particular issues that may merit regulator attention include:

- Projected impacts of climate change vary substantially by state,[11] as does the vulnerability of insurers. Current national data tend to gloss over local variations,

[11] The scientific community is increasingly providing analysis and information on potential impacts at the state level, which provides for a more meaningful analysis grid than the national or even global level of

e.g., differences in state-by-state reserves and probable maximum losses (see Figure 10). Regional climate modeling and scenario studies may help illuminate this issue.

- There is at present a poor level of understanding of the potential impact of climate change. An important example was the All-Industry Research Advisory Council (AIRAC) (1986). This work surprised the insurance community by quantifying the considerable effect of multiple mega-catastrophes within a relatively short time period. It is remarkable that this work has not been replicated and updated over the intervening 15 years. It would be prudent for regulators to foster such analyses.

- There are also insufficient data on current and historic losses. For example, as described above, the PCS data exclude a significant amount of weather-related losses. The most dramatic example is probably soil subsidence during drought conditions, the total annual costs of which are collectively on a par with a major hurricane, yet these costs go entirely unrecorded due to their distributed nature and small per-event loss amount. It would be prudent for insurers to improve their data gathering and analysis activities.

- Current loss modeling is clearly inadequate for assessing prospective climate risks. Part of the problem resides in the way in which CAT models base their projections on past experience. Similarly, CAT models have yet to be coupled with climate models. Regulators could promote innovation in this area, enabling the industry to make a constructive contribution to understanding and quantifying the risks, although there seems to be a difference of opinion on the potential for this:

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detail that characterized their work in the 1990s (USGCRP, 2000). See also the following Web site for state-level information: www.epa.gov/globalwarming/impacts/stateimp/index.html.

"It seems clear that the best role for insurers in the debate on global warming is that of expert witness. We can bring our knowledge and expertise in calculating potential loss to assist policymakers and the general public in understanding the complex issues involved."

-- Sean Mooney, research director and economist, Guy Carpenter & Company (1998)

"[T]he insurance industry does not have the expertise to evaluate conflicting interpretations of scientific evidence or positions on climate change."

-- American Insurance Association (1999)

- Some experts in corporate governance project that company officers could be held accountable for failing to protect their companies from climate-related risks, with lawsuits coming from governments as well as investors (Cortese, 2002). This could result in insured liability losses for executives and directors or claims directly against insurers. The issue has been likened to the tobacco liability cases of the 1990s. This concern is intensified in the current environment of apprehension about "off-balance-sheet" risks.

- Perhaps the largest public policy issue embedded in the climate-change discussion is whether the standards of insurability will call for shifting of risks to the insureds and the public sector (as is currently the case with most flood and crop/hail risks). Regulators will have to grapple with the fact that the public sector is reluctant to assume such risks (as can be seen from the current debate on federal terrorism reinsurance), and is seeking to limit its own exposures to losses and to cap its expenditures on disaster preparedness and recovery.

- Some proactive insurer responses (e.g., promoting the more efficient use of energy) are often impeded by regulations. For example, insurers generally need regulatory approval for providing incentives to insureds to pursue loss-prevention

strategies or to invest in sustainable energy industries. Similarly, the exclusion of research and development expenses from rates may stifle innovation in this area.

- Regulators' counterparts in other sectors (energy, transportation, forestry, building codes) are already active in areas that pertain to climate change. Insurance regulators have yet to claim their place at the table in some of these discussions (political as well as technical); e.g., the safety-efficiency-tradeoff question of fuel-economy standards for automobiles and trucks.

Conclusions

Although the notions of risk management and loss prevention are embedded in the historical fiber of the insurance industry, U.S. insurers have yet to fully extend this thinking to the matter of climate change. They have treated loss control as a relatively "local" enterprise. It entails a rather dramatic shift in self-perception to engage in the activity at a (literally) global scale.

Over the past decade, U.S. insurers, to their credit, have been involved in a number of activities in which the question of weather-related losses (and in some cases climate change itself) have been addressed. One very positive characteristic of some past efforts is the warming to a multidisciplinary approach, in which occasional partnerships with groups outside the insurance sector have been profitably created. What does not emerge, however, is an indication that these activities have built upon one another toward some sort of consensus on the matter or toward a coordinated plan of action extending beyond very preliminary discussion and fact-finding activities.

We are already hearing calls from within the natural-hazards community for a more holistic approach, one that integrates environmental protection with the discipline of disaster risk management (Mileti, 1997). The often-invoked notion of sustainability is a compelling one, and it been embraced by some as a planning framework for the long-term health and viability of the insurance industry and other parts of the economy. In its

fullest form, it calls for integrating business sustainability and environmental sustainability, as opposed to a rarified ecological construct separated from real-world economics. Insurers should not be expected to champion this goal unilaterally, but rather as an important partner in a broader mosaic of public and private interests (Kunreuther, 2000). In fact, insurers and their regulators are the last major United States industry to "come to the table" on climate change. Their views would make a material contribution to the discussion.

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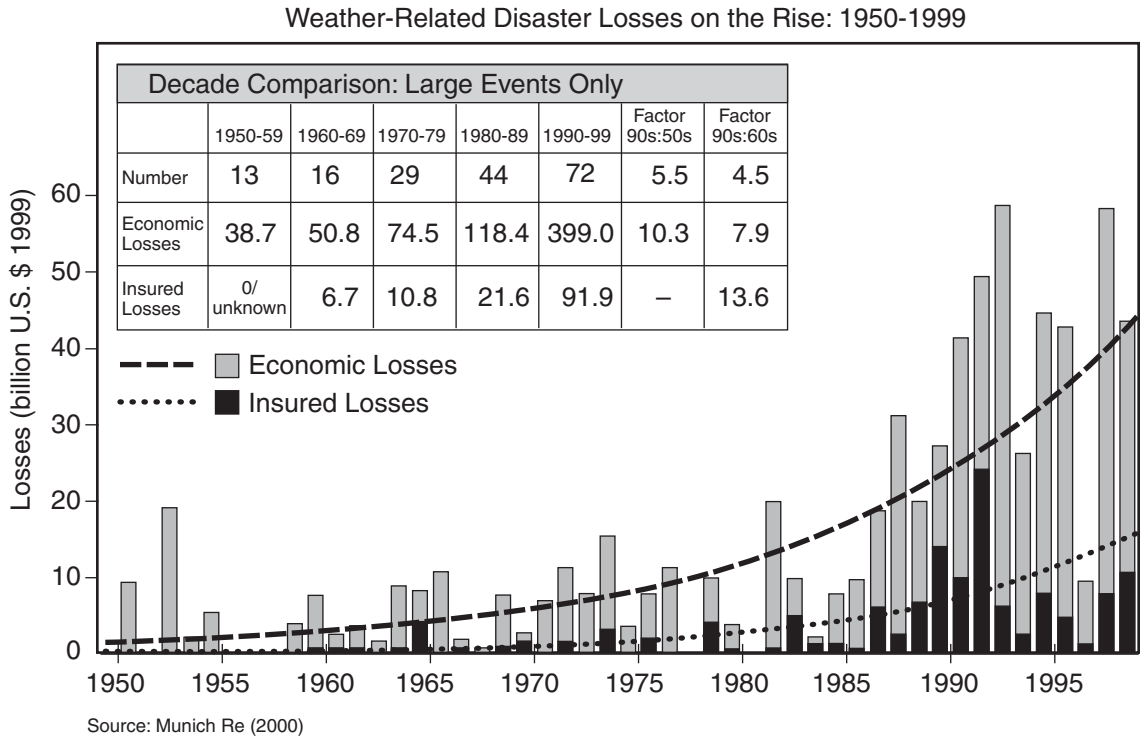
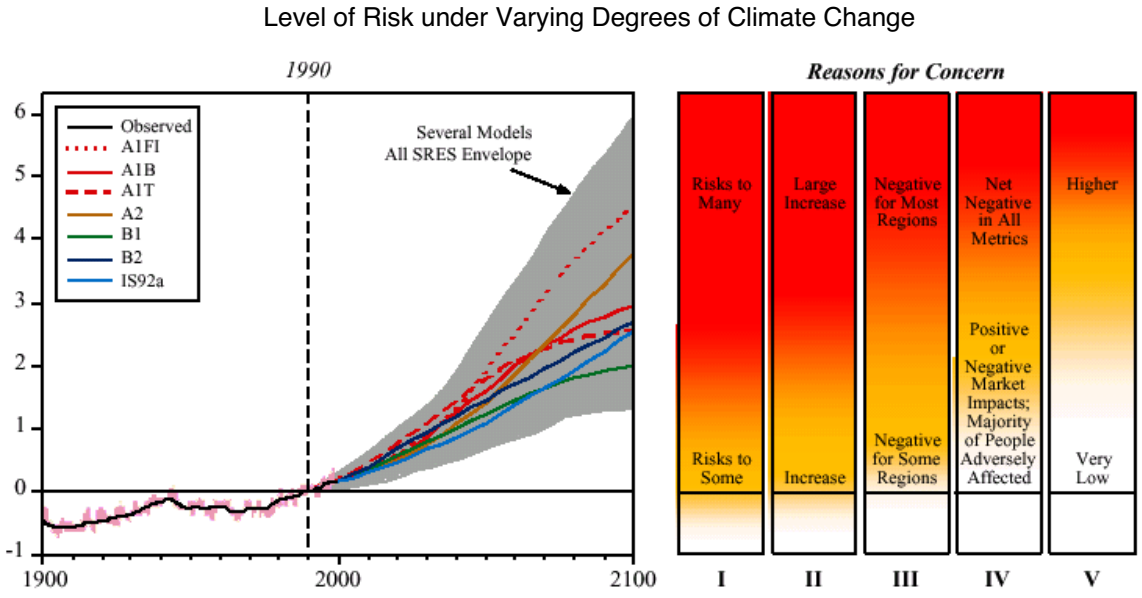
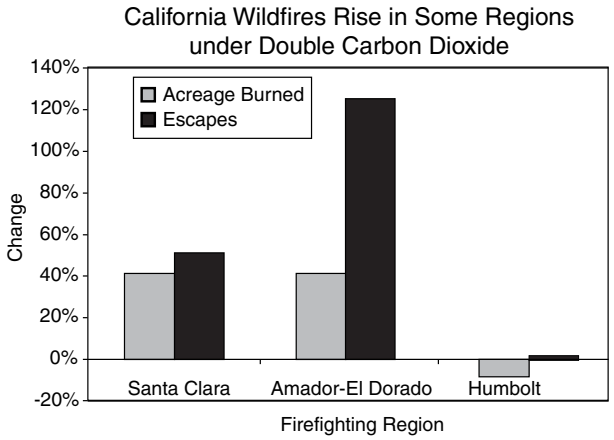


Figure 1. Note: by including events of all sizes these totals would increase by approximately a factor of two. The cost data are adjusted for inflation. Population growth during 1950-1999 was 2.4-fold. Source: (Munich Re 2000).



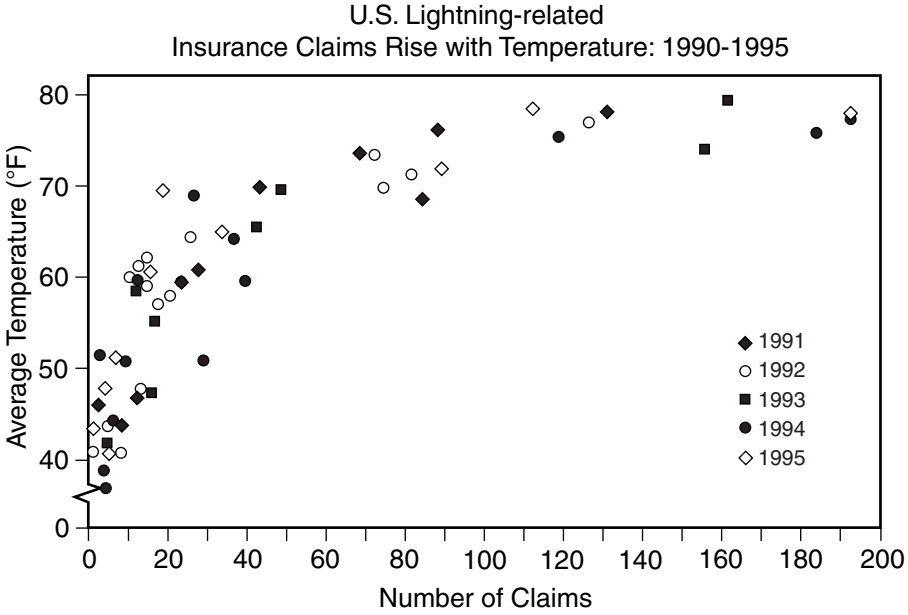
Legend I = Unique and threatened species and natural systems; II = Extreme climate events; III = Distribution of impacts; Global aggregate impacts; V = Large-scale, high-impact events.

Figure 2. The left-hand chart shows the envelope of temperature-rise predictions from the latest IPCC Assessment (Watson et al. 2001). The chart to the right shows the relative risks/benefits in various sectors associated with the range of projected temperature increases.



Source: Torn *et al.* (1998)

Figure 3. Under climate change, wildfire damage would increase in intensity and severity. This is illlustrated by the projected rise in acreage burned and catastrophic "escaped" fires in California under double-carbon dioxide conditions by the middle of this century, i.e., 110 additional escapes in an average year and an additional 12,000 acres burned by contained fires. These values capture the extent of fire damage given maximum use of California's existing fire-suppression infrastructure. Note that "escapes" represent a very small percentage of total fires, but the majority of fire-related damages. California already spends $300 million per year on initial attack fire protection; it is conceivable that this might have to be increased by 50% or more to maintain the current escape rate (Torn *et al.* 1998; Fried *et al.* 2002). The largest U.S. wildfire insurance loss was the $1.8 billion Oakland Hills Fire in 1991, in which one reinsurer noted that climate change may have been implicated (Swiss Re 1992).



Source: Hartford Steam Boiler Inspection and Insurance Co. claims data (2000).
Each symbol represents a lightning storm event.

Figure 4. Lightning-related insurance losses (e.g., due to equipment breakdown and electricity service disruption) correlate strongly to temperature. An additional issue is that peak lightning periods occur in summer, when electricity reliability problems are likely to cause other business interruption losses, as suggested by the illustration. Climate change can be expected to increase lightning events and the associated insurance losses. Source: Hartford Steam Boiler Insurance and Inspection Company claims data.

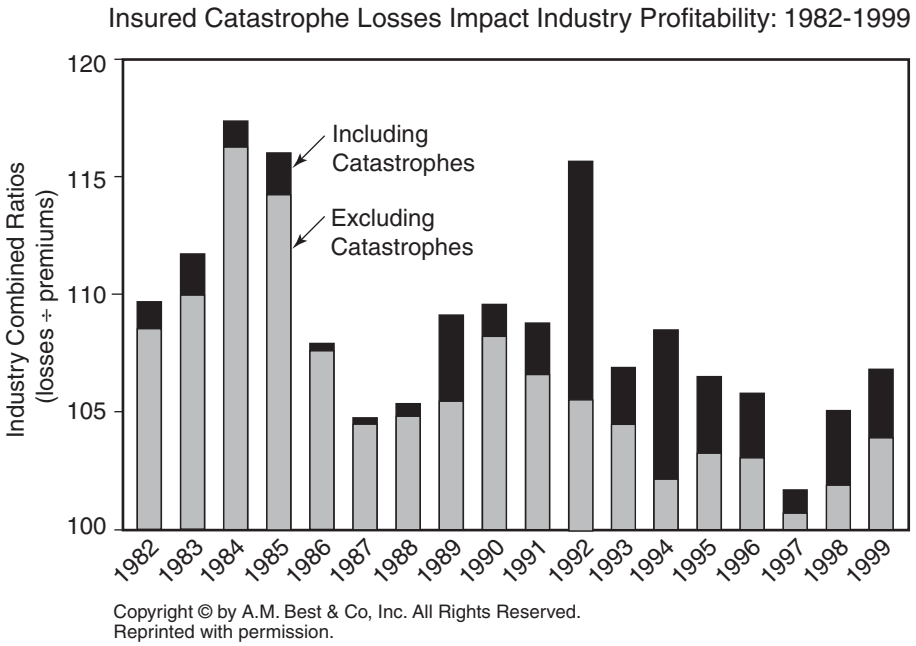


Figure 5. Catastrophe losses have played a significant role in the insurance industry's underwriting results in recent years, particularly in 1989 (hurricane Hugo), 1992 (hurricane Andrew), and 1994 (Northridge Earthquake). The impact on the industry's combined ratio in 1999 was 2.9 points primarily due to tornadoes, wind, and hail that hit Oklahoma and 17 other states in May. Source: A.M. Best Co. (2000).

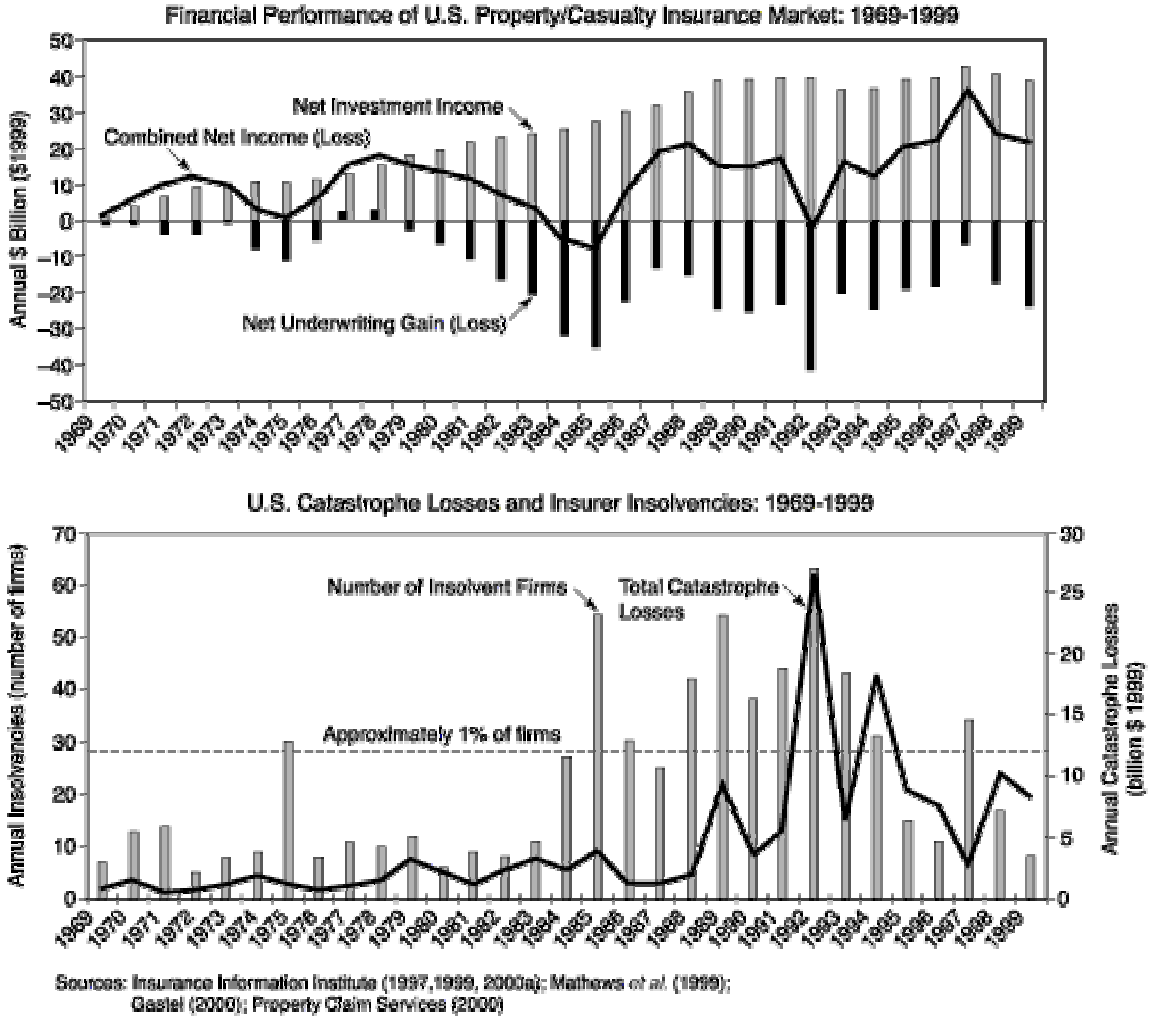


Figure 6a-b. Profitability and solvency of U.S. property/casualty insurers during periods of natural disasters. (a) Sensitivity of U.S. property/casualty insurance sector net financial results to investment income and underwriting gain/loss. Curve is the net result (Insurance Information Institute 1997, 1999, and 2000a; Matthews et al. 1999). (b) Annual number of U.S. insolvencies (from all causes) and natural disaster losses: 1969-1999. Costs corrected for inflation using GDP deflators. Includes insured losses of >$5m through 1996 and >25 million beginning in 1997. Note that due to various lag times insolvencies do not necessarily take place in the same year as the precipitating event**.** Sources: (Matthews *et al*. 1999; Gastel 2000; PCS 2000; Insurance Information Institute).

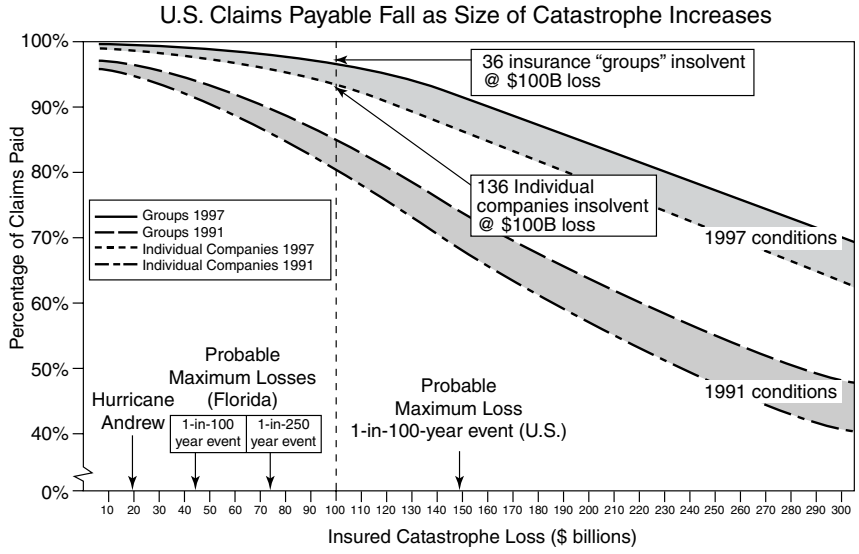


Figure 7. The chart shows four views of the ability of the property-casualty insurance sector, as a whole, to pay claims over a wide range of losses, encompassing changes in capacity between 1991 and 1997 and whether or not companies have access to the resources of Groups that own them. For a $155 billion loss year in one year--a recent estimate of Probable Maximum Loss (GAO 2000)--65% to 90% of claims would be paid. The improvement in vulnerability between 1991 and 1997 is attributed largely to the performance of insurers' investments in securities during that period (GAO 2000), however surplus fell by $13 billion between 1999 and 2000 as the favorable market conditions reversed (ISO and NAII 2000). Sources: curves and $100-billion event impacts are from Cummins *et al*. (1999); other PML benchmarks from GAO (2000).

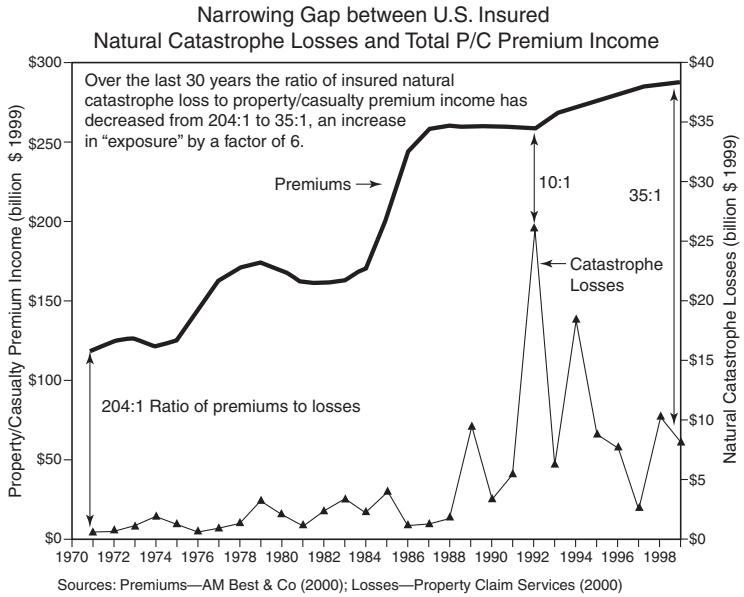


Figure 8. Exposure, measured as the ratio of premiums/losses, rose by a factor of 6 over the period. Small values correspond to relatively high exposure. The exposure ratio ranges from 204:1 in 1971 to 10:1 in 1992, the year of Hurricane Andrew. Note that the loss data include only major natural catastrophe losses. Premiums include significant revenues from non-weather-related business segments. Sources: Premiums (A.M Best & Co. 2000); Losses (PCS 2000).

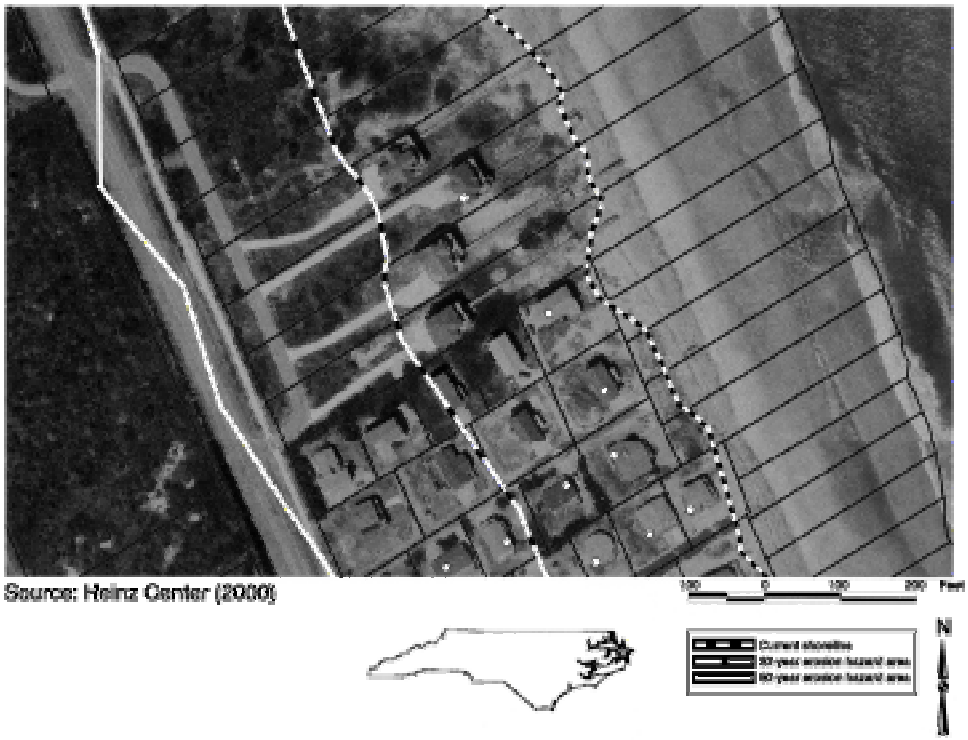


Figure 9. As shown on this aerial photo of Nags Head, North Carolina, the beach is expected to erode inland about 550 feet (to the heavy dashed line) over the next 60 years. Five rows of houses, marked with dots, are likely to be lost to erosion over this period Source: Heinz Center 2000.

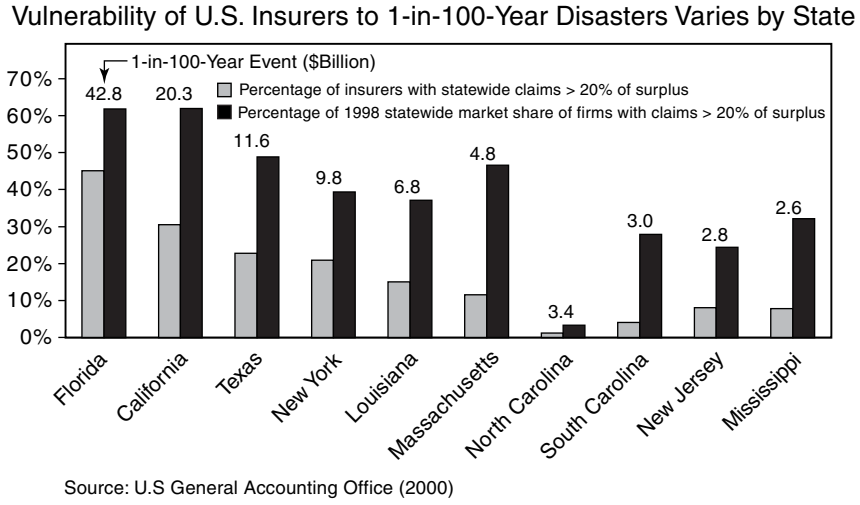
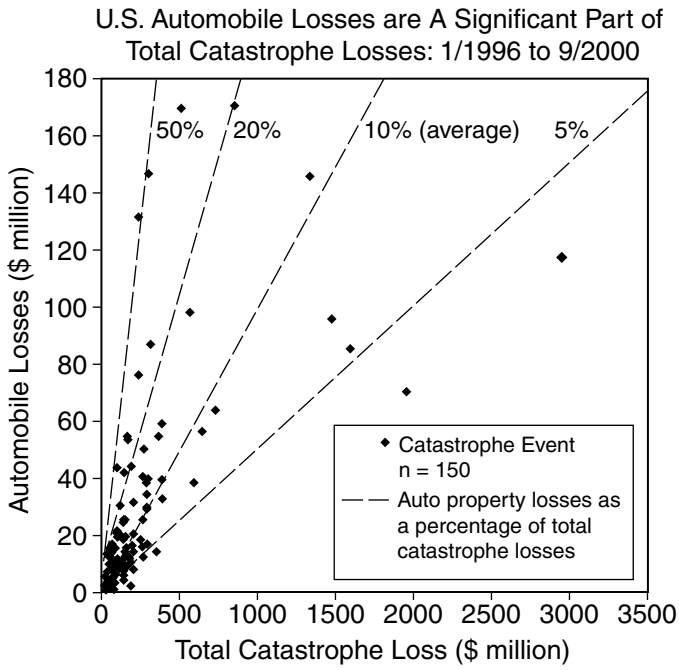


Figure 10. Excludes reinsurance, and local government-supported insurance or reinsurance programs in California and Florida, and the effects of catastrophes striking more than one state (e.g. the estimated 1-in-100-year loss for the entire U.S. is $155 billion). The capacity implied may include some surplus amounts not available for paying natural catastrophe claims. Losses that result in claims of over 20% of surplus trigger the initial stage of formal solvency review by NAIC. Puerto Rico (not shown) has a 1-in-100 year loss of 27.1 billion. Source: (GAO 2000).

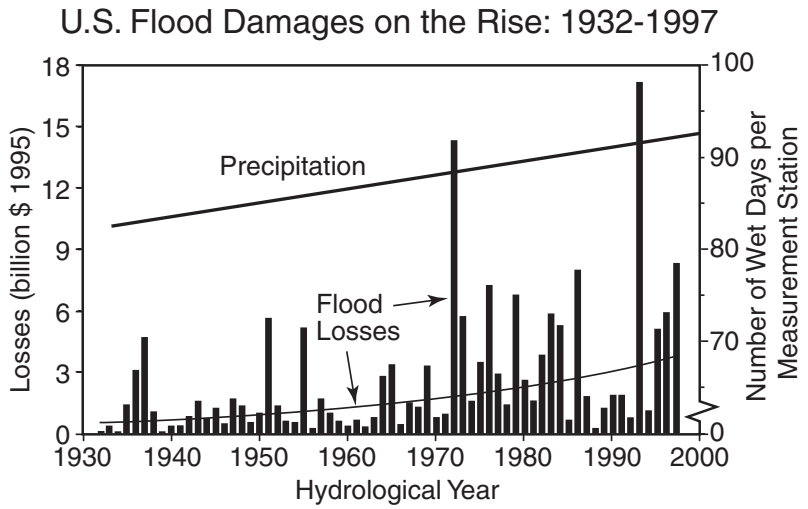
1 BOX 1. AUTOMOBILE LOSSES AND NATURAL CATASTROPHES



Source: Property Claim Services (2000)

In the U.S., 16% of automobile accidents are attributed to adverse weather conditions as are one-third of the accidents in Canada. Autos also sustain insurance losses during natural disasters, amounting to $3.4 billion and 1.7 million claims between 1/1996 and 9/2000 (PCS 2000) and averaging 10% of total disaster-related property losses, with much greater losses for some events, particularly hailstorm. Individual events have seen as much as 55% of total losses attributed to autos. These data systematically underestimate total losses because PCS records include only those events with total losses of $25M or more (NHTSA 1999; White and Etkin 1997).

Box 2. Flood Risks and Climate Change



Source: Pielke and Downton (2000)

Note: A trend is also visible when results are normalized to per-capita losses and correlates to an increase in precipitation. Values shown in the chart are inflation-corrected insured and uninsured losses. Source: (Pielke and Downton 2000).

Precipitation and associated flooding losses are consistent with what is expected under climate change, and are expected to rise in the future. Flood is one of the most formidable weather-related hazards, with total U.S. economic costs of $31.1 billion over the past 15 years (Munich Re 2000), of which $3.8 billion were commercially insured. The ten worst floods in recent U.S. history resulted in private insurance claims of U.S.$2.5 billion (nominal dollars), and all but one of which took place during the eight-year period of 1989-1996 (Insurance Information Institute 2000). One insurer--FM Global--reports an average of $100 million in flood insurance losses annually, and they caution that historic flood losses should not be used as a proxy for potential future losses (Hofmann 2000). Compared with other natural hazards, the scientific community identifies relatively clear connections between flood and climate change (Karl and Knight 1998; Aldred 2000). Climatologists at Arkwright Mutual (one of the firms to merger into FM Global) and elsewhere have concluded that flood losses have been increasing for physical reasons (in addition to demographic changes) and that climate change could be one factor at work in this change (Zeng and Kelly 1997; Pielke and Downton 2000). The Association of British Insurers has also expressed concern about growing flood-related losses under climate change (Business Insurance 2000). Insurers have cautioned that flood plain maps are out of date and that political pressures can lead to the underestimation of flood risks (Hofmann 2000). While federal flood insurance plays a central role in assuming flood exposures, private insurance is also used and ancillary losses, e.g. business interruption or equipment breakdown, are typically commercially insured (Wojcik-Kochaniec 1999). Coastal erosion (related to tidal surges or flooding) is also a growing risk for private insurers and governments alike (Heinz Center 2000).